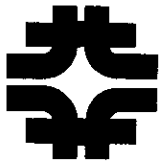


Fermi National Accelerator Laboratory

United States Large Hadron Collider Accelerator Project

FERMILAB LHC ACCELERATOR PROJECT QUALITY ASSURANCE PLAN Version 1

Approved, Technical Division Quality Assurance Officer	21-Nov-2001 Date
Approved, US-LHC Fermilab Project Manager	21-Nov-2001 Date
Approved, US-LHC Project Manager	21 Nov 01 Date
Approved, Technical Division Head	21 Nov 01 Date

Purpose

The purpose of this Quality Assurance Plan is to describe how quality assurance is planned and implemented for Fermilab's effort on the US-LHC Accelerator Project.

Each section of this document begins with a policy statement for the Technical Division. Fermilab's portion of the US-LHC Project adheres to the TD policies, unless otherwise stated.

Scope

The description and requirements in this plan are applicable to all activities included in Fermilab's portion of the US-LHC Accelerator Project (hereafter referred to as 'the Project').

Reference Documents

1. US-LHC Project Management Plan, available from http://tdserver1.fnal.gov/project/Us-lhc_official_docs/Governing_docs/PMP/
2. US-LHC Technical Design Handbook, available from http://tdserver1.fnal.gov/project/Us-lhc_official_docs/Controlled_docs/Technical/
3. Technical Division Quality Management Program TD-2010, available from http://www-td.fnal.gov/ (under "Tech Division Info")
4. Technical Division Self-Assessment Program TD-2020, available from http://www-td.fnal.gov/ (under "Tech Division Info")
5. Fermilab Procurement Manual, available from http://www-bss.fnal.gov/Procurement/
6. Fermilab Environmental, Safety & Health Manual, available from http://www-esh.fnal.gov/home/esh_home_page.page?this_page=800
7. Measurement & Test Facility magnet Run Plans, available from http://wwwtsmtf.fnal.gov/~tartagli/LHC/LHC.html

CERN documents (available from http://www.cern.ch/CERN/Divisions/EST/LHCQAP/qaphome.htm)

8.	Quality Assurance Policy and Project Organization	LHC-PM-QA-100.00
9.	Quality Assurance Contents and Status	LHC-PM-QA-101.00
10.	Quality Assurance Categories	LHC-PM-QA-201.00
11.	Glossary, Acronyms, Abbreviations	LHC-PM-QA-203.00
12.	LHC Engineering Vocabulary	LHC-PM-QA-205.00
13.	LHC Part Identification	LHC-PM-QA-206.00
14.	Drawing and 3D Model Management and Control	LHC-PM-QA-305.00
15.	Drawing Process - External Drawing	LHC-PM-QA-306.00
16.	Design Process and Control	LHC-PM-QA-307.00
17.	Manufacturing and Inspection of Equipment	LHC-PM-QA-309.00
18.	Handling of Nonconforming Equipment	LHC-PM-QA-310.00

CERN documents (available from http://rvuiller.home.cern.ch/rvuiller/Tisus/coordination.htm)

19.	MOU on Accelerator Mechanical Safety	TIS-TE-MB-98-74
20.	Weld Inspections on FNAL Q2a and Q2b Quadrupoles	

CERN document (available from at http://lhc.web.cern.ch/lhc/, under "LHC Design")

21. LHC Parameters and Layouts Database

1.0 Program

1.1 *Policy*

The policy of the Technical Division is to develop, document, and maintain its quality management program, so that the division may satisfy the needs of its customers.

1.2 *Mission*

The mission of *Fermi National Accelerator Laboratory* is:

"Advancing the understanding of the fundamental nature of matter and energy by providing leadership and resources for qualified researchers to conduct basic research at the frontiers of high energy physics and related disciplines."

The mission of the *Technical Division* is:

"The development, design, fabrication or procurement, and testing of accelerator and detector components."

The mission of the *US-LHC Accelerator Project* at Fermilab is to:

1) Design, build, and test interaction region quadrupole cold masses;
2) Design, build, and test interaction region quadrupole cryostats;
3) Assemble Fermilab and KEK-built quadrupole cold masses into Fermilab-built cryostats;
4) Ship the completed quadrupole assemblies to CERN.

1.3 *Objectives, Goals and Functional Responsibilities*

[1] <u>To design and fabricate cold masses and cryostats</u>.

The Engineering & Fabrication Department is responsible for the design of the manufacturing tooling and the cold masses and cryostats that are required in the Project.

[2] <u>To procure, inspect, inventory, and deliver the various materials needed for this project</u>.

The Material Control Department is responsible for these functions. The Engineering & Fabrication Department interfaces with the Material Control Department and other groups, as required, to assist the procurement section of Fermilab in procuring the needed material.

Inspection of the procured materials will be required. See section 8.0 for details. The storage and inventory of the components for the assemblies may be required in some cases.

[3] To test the completed assemblies.

The Development & Test Department is responsible for the design and fabrication of the test equipment, and for testing the completed assemblies. See section 8.0 for specifics on Inspection and Acceptance Testing.

[4] To oversee the scheduling of milestones, to budget and control cost, and to report to the US-LHC Project Manager timely status reports, as required by the project office.

These functions are assigned to the Fermilab Project Manager, who is assisted by his staff and other project personnel. This includes reporting on the resource requirements and status of the project to the Technical Division Head.

[5] To create and maintain a Quality Assurance Plan.

Although quality is the responsibility of every Fermilab employee, the task of creating and maintaining the QA Plan is assigned to the Quality Assurance Officer.

[6] To perform the required material development for this project.

This task is assigned to the Material Development Laboratory in the Engineering & Fabrication Department, on an as-needed basis.

[7] To provide a qualified staff for the performance of this project and to provide the needed laboratory work space.

This function is the responsibility of the Technical Division Head, acting on input supplied by the Fermilab Project Manager.

1.4 *Organizational Structure*

The organization chart for the Project is defined in Appendix 4 of the US-LHC Project Management Plan (PMP). A more detailed chart is located in Appendix I.

Clear and frequent communication is always encouraged among the project participants, and is critical to the success of the Project. Informal communication via notes, phone calls, electronic mail, and informal discussions are exchanged frequently between the participants. This information flow encourages the exploration of the viability of plans and solutions, and allows for the resolution of any issues that arise. Although it is not a project requirement, the distribution of copies of informal correspondence to all participants is desirable to keep everyone apprised of the most

current information available. More information regarding project communications is defined in section 3.4 of the US-LHC PMP.

1.5 *Roles, Responsibilities and Authority*

1.5.1 Fermilab Project Manager

- Fermilab Project Manager reports to the US-LHC Project Manager;
- Is responsible for delivering acceptable completed quadrupole assemblies to CERN;
- Implements the QA Plan;
- Assures the quality of the delivered products;

More details regarding the responsibilities for the Fermilab Project Manager are defined in section 3.3.5 of the US-LHC Project Management Plan (PMP).

1.5.2 Level 3 Managers

- Level 3 managers are responsible for the day-to-day coordination and progress of the WBS Level 3 task to which they are assigned.

More details regarding the responsibilities for the Level 3 managers are defined in section 3.3.7 of the US-LHC PMP.

1.5.3 Quality Assurance Officer

- Responsible for the creation and maintenance of the QA Plan;
- Responsible for aligning the requirements of the CERN LHC QA Plan with the practices of the Project, and identifying differences as appropriate.
- Responsible for providing support to the US-LHC project staff throughout the project.

1.5.4 Technical Division Head

- Provide support to project personnel, and aid in solving problems that cannot be solved on a lower level.

1.6 *Organizational Interface*

1.6.1 Fermilab LHC Project Office/US-LHC Project Office

- As stated above, the Fermilab LHC Project Manager reports to the US-LHC Project Manager. The Fermilab LHC Project Manager is responsible for following the guidelines set up by the US-LHC Project Office, and for reporting on the status of the Project;
- All Project documents that are to be approved by CERN, e.g. specifications, are routed through the US-LHC Project Office.

1.6.2 Fermilab LHC Project Office/TD-HQ

- Communicate project status on a regular basis and when changes occur;
- Determine staffing requirements for the Project within TD;
- Resolve resource allocation issues, e.g. draftsman assignments, machine shop priorities, and space allocation.

1.6.3 Technical Division Procurement/Fermilab Business Office

- TD Procurement representative attends weekly Project design/procurement meetings with the Fermilab Business office;
- Project management attends these meetings as needed.

1.6.4 Fermilab LHC Project Office/Level 3 Managers

- Develop requirements and specifications to fulfill the goals of the Project. The Fermilab Project Manager will approve requirements and specifications.

1.6.5 Fermilab LHC Project Office/CERN

- As CERN is the customer of the US-LHC project, regular communication is necessary for a successful completion of the Project. Conversations (via telephone, e-mail, video conference, travel, et cetera) frequently take place between the Fermilab Project Manager, Fermilab Project Engineers and CERN LHC representatives. As the Project advances, these conversations are recorded in drawings and specifications, and are approved by appropriate personnel;
- In addition, CERN supplies several parts used in the inner triplet final assembly. Communication between the Project and CERN also include defining and documenting the requirements related to these parts.

1.6.6 Fermilab LHC Project Office/KEK

- KEK is responsible for the design and manufacture Q1/Q3 cold masses. Fermilab is responsible for final assembly of KEK cold masses into the cryostats. This means that conversations (via telephone, e-mail, video conference, travel, et cetera) frequently take place between the Fermilab Project Manager, Fermilab Project Engineers and KEK LHC representatives. As the Project advances, these conversations are codified, and approved by appropriate personnel, in drawings and specifications.

1.7 *CERN LHC QA Plan*

The CERN QA Plan has been read and understood by the QA Officer. Links between current Project practices and CERN QA documents have been incorporated into this document. The Technical Division QA program, as defined in this document and implemented for the production of LHC devices, meets all requirements defined in the CERN QA Plan.

2.0 Personnel Training and Qualifications

2.1 *Policy*

The policy of the Technical Division is to hire and maintain personnel who posses the appropriate level of skill, experience, and academic qualifications to support the achievement of the Project.

2.2 *Training*

All Project personnel (including contract personnel) have the appropriate experience and/or are provided training to ensure that they are capable of performing their assigned work to the appropriate level of safety, efficiency and quality.

Training may come from several sources such as mentoring provided by physicists, engineers, supervisors, lead personnel, consulting firms, technical operating manuals, and other sources. Job-related training records of all assigned personnel, for work related to the Project, are maintained by the respective supporting organization.

2.3 *Qualifications*

Qualifications for personnel working on the Project are based upon the responsibilities of the position and project needs, which define the level of education, extent of work experience, knowledge and specific skill requirements.

3.0 Quality Improvement

3.1 *Policy*

The policy of the Technical Division is to continually improve in all areas and activities for which it is responsible.

3.2 *Quality Responsibilities*

All personnel performing a function at Fermilab are responsible for quality and are encouraged to promptly report conditions adverse to quality such as deviations, deficiencies, failures, defective items or processes, and nonconformances, to the appropriate level of management.

Personnel closest to the daily operation or activity are in the best position to understand and report nonconforming conditions, and are encouraged to participate in quality improvements to meet the needs of the customer and to achieve the objectives of the project mission.

Management is responsible for providing the necessary resources for conducting root cause analysis and for implementing corrective and preventive actions.

3.3 *Performance Analysis*

The "Quality Control Report" and "Discrepancy Report" processes, described below, meet the requirements of CERN QA document LHC-PM-QA-310.00 "Handling of Nonconforming Equipment".

3.3.1 Supplier Performance

Supplier performance problems are identified and reported through the mechanism of Quality Control Reports (QCRs), generated by the Material Control Department's Incoming Inspection group for items such as incoming parts, assemblies, and hardware. These reports are reviewed and approved by the responsible authority/physicist (or designee) of the area or activity in which they will be used and by the Material Control Department Head (or designee). The review covers problems that may have significant programmatic effect or risk factors affecting cost, schedule, ES&H (personnel safety), or configuration. The appropriate disposition is given, i.e. scrap, return to vendor for replacement, rework at vendor, rework in house, or use as is. These reports are reviewed for supplier performance problems or trends and are used as a basis for cause analysis and necessary corrective action.

3.3.2 Work Process Performance

Discrepancy Reports (DR) are used to document problems during assembly or fabrication such as deviations, deficiencies, failures, defective items/materials or processes, malfunctions, trends, and/or non-conforming conditions.

The responsible authority of the activity or area of occurrence reviews these discrepancy reports for technical evaluation, cause determination, disposition, and corrective/preventive action recommendation. If rework is required, instructions are recorded on the DR form. After rework is completed the item is retested against the specification and is dispositioned accordingly.

Process Engineering performs a review of these reports to ensure that reports are completed properly and that preventive action is adequate; the QA Manager may also recommend follow up corrective/preventive action or verification/validation as required. These discrepancy reports are used as a basis for trends, cause analysis, and/or lessons learned.

4.0 Documents and Records

4.1 *Policy*

The policy of the Technical Division is to maintain adequate documentation and records to ensure quality requirements are met, while recognizing the objective of minimizing paperwork and overhead cost.

Detailed documentation of all Project components, from design, continuing through all fabrication and testing processes, until final performance measurement, are essential, as Fermilab personnel will not be involved in the operation and maintenance of the LHC.

4.2 *Responsibilities*

- Quality Assurance is responsible for the release, revision and distribution of the Project QA Plan.
- The Engineering & Fabrication Department is responsible for the control of documents and data pertaining to engineering specifications, engineering procedures, cold mass and cryostat drawings and travelers.
- The Development & Test Department is responsible for the control of documents and data regarding completed assembly performance testing.
- The Material Control Department is responsible for the control of documents and data associated with the procurement of materials for the Project.

4.3 *Procedures*

4.3.1 Controlled Documents

Controlled documents are created, implemented, and maintained at a level commensurate with the level of work being performed and as dictated by sound quality assurance practices.

The Project maintains the following documents under document control:

- US-LHC Fermilab Quality Assurance Plan
- Engineering drawings and specifications
- Travelers

All controlled documents:

1. Are reviewed and approved by authorized personnel prior to being issued/revised.
2. Have a revision history maintained.
3. Are available to all personnel who need access.

4.3.2 Drawing and 3D Model Management

- Fermilab utilizes its internal drawing management system to create, approve, release and manage Project drawings.
- Fermilab will deliver HPGL plot files of 2-D drawings to CERN.
- All specifications, and their associated drawings, are sent to CERN prior to starting full production. The remainder of the drawings are provided after production has started, but before the first device is shipped to CERN.
- "As-built" drawings will be sent with the device. Device labels include the appropriate version of the assembly drawing.
- The Project's practices for managing drawings and 3D models meet the intent of CERN QA documents LHC-PM-QA-305.00 "Drawing and 3D Model Management and Control" and LHC-PM-QA-306.00 "Drawing Process - External Drawing".

4.3.3 Quality Records

Along with the records defined in section IV of the Safety MoU, the Project provides CERN the following records for each delivered device:

- A set of completed travelers - hard copies sent with the completed assembly and scanned copies provided to CERN;
- All Discrepancy Reports issued during the assembly process - hard copies sent with the completed assembly and scanned copies provided to CERN;
- Results of the performance measurements - a hard copy summary is sent with the completed assembly and electronic files provided to CERN.

Scanned images are provided to CERN in Adobe® Portable Document Format (PDF)[1].

The procedures and practices used by the Project to manage records meet the requirements defined in section 12 of CERN QA document LHC-PM-QA-309.00 "Manufacturing and Inspection of Equipment".

[1] Adobe PDF is a trademark of Adobe Systems Incorporated in the United States and/or other countries.

5.0 Work Processes

5.1 *Policy*

The policy of the Technical Division is that work processes be well thought out, appropriately documented and reviewed, and that they be carried out by competent and effective workers.

5.2 *Responsibilities*

- The Fermilab Project Manager's responsibility, as defined in 1.5.1, includes administering, planning, organizing, and controlling the Project to meet the technical, cost, and schedule objectives.
- The individual Project worker is the first line in ensuring quality. They are responsible for following the procedures defining the assembly and quality control checks in the fabrication of the assemblies, i.e. travelers. They also have the authority to report any possible nonconformities to management, and may participate in cause analysis and continuous improvement.
- The department heads are responsible for ensuring that people who are assigned to tasks have the appropriate academic qualifications, professional certifications, or skills and experience to carry out the work successfully (see section 2).
- The Fermilab Project Manager and the Project engineers are responsible for planning, authorizing, and specifying (to an appropriate level of detail), the conditions under which work is to be performed. This includes the calibration of measuring and test equipment (see section 8). This group also specifies which work is sufficiently complex or involves sufficient hazard to be performed to written procedures.
- The Engineering & Fabrication Department is responsible for the inspection and test status, identification and traceability, and for the creation and maintenance of the travelers for the magnets (see section 5.4).
- The Material Control and Engineering & Fabrication Departments share responsibility for the handling, storage, and preservation of components and completed assemblies.

5.3 *Production Process Control*

Appendix II defines the workflow for the fabrication of the Q2 magnet assemblies, which are built entirely at Fermilab. It identifies each process step, the traveler number(s), the serialization method, and the quantities of each sub-assembly needed to build one complete assembly. For the Q1 and Q3 assemblies, whose cold masses are provided by KEK, only the last two steps are executed. These will have their own traveler document numbers and assembly serial number series.

The Engineering & Fabrication Department Head, in conjunction with the Fermilab Project Manager and Project engineers, is responsible for ensuring that production

processes are carried out under controlled conditions. When planning the production processes, the following are considered:

- All applicable government safety and environmental regulations;
- Use of travelers (or other such work instructions) to document the methods of production. These should be used when the absence of such procedures could be adverse to quality;
- Defining suitable equipment and work environment to ensure quality;
- Defining suitable maintenance of equipment to ensure continuing process capability;
- Defining the criteria for workmanship in the clearest practical manner. Examples of this are work instructions that document tolerances for process parameters, samples or pictures of "quality" product, samples or pictures of poor quality or failure modes to look for;
- Level of education and experience required for production personnel;
- Training needs for production personnel.

The procedures used to control production meet the requirements defined in section 5.3 of CERN QA document LHC-PM-QA-309.00 "Manufacturing and Inspection of Equipment".

5.4 *Travelers*

A system of travelers is used to define the sequence of fabrication, inspection, and testing to be performed for the assemblies. Witness/Hold points are designated in travelers at a turning point or important juncture of the fabrication. Travelers provide for sign-off by qualified personnel and are dated at the completion of each fabrication sequence, welding operation, and inspection/test procedure by designated inspection/test personnel, fabrication personnel, or welding personnel to assure completion, date completed, and sequence of required operations.

Training of project personnel in the usage of travelers is accomplished with a "walk-through". The "walk-through" training is conducted and documented by Process Engineering. The initial training simulates an actual operation (e.g. coil winding) using the traveler in a step by step sequence. The goal of the initial training is to familiarize all personnel with the proper usage of travelers in general, as well as to help everyone understand how the particular operation is designed to be completed.

Subsequent training of traveler revisions may be accomplished by routing the revised traveler to the appropriate personnel for signature, signifying that the revised traveler has been read and understood.

5.5 *Identification, Traceability and Test Status*

All finished components are identifiable with names and serial numbers that are located on the unit and its accompanying traveler(s). Serial numbers are marked on the unit

according to the *Cryostat Final Assembly Traveler* (333644), which meets the requirements in CERN QA document LHC-PM-QA-206.00 "LHC Part identification" and section 7 of LHC-PM-QA-309.00 "Manufacturing and Inspection of Equipment".

Sub-assemblies are identified appropriately. The method of identification depends on the sub-assembly and the scope of the label. Some possible identification methods include:

- A stamp or label containing pertinent information is placed on the device;
- A tag containing pertinent information is affixed to the device;
- Serial numbers may be assigned if the device is sufficiently complex (the use of a traveler to fabricate a sub-assembly usually means that the sub-assembly is assigned a serial number);
- Sometimes a sub-assembly will have no physical label, in which case we rely on people, and the corresponding drawings, to identify the parts.

The lot/batch/serial numbers of the parts going into the unit are recorded on the traveler, and so it is the traveler that is the main document used for traceability.

While it is being fabricated, the test status of the unit is identifiable using the accompanying traveler, i.e. the traveler will show how far along the unit is in the assembly and test process, as well as the results of the QC checks. When the unit is completely assembled, it is tagged showing the test status. The methods used to identify test status meet the requirements defined in section 14 of CERN QA document LHC-PM-QA-309.00 "Manufacturing and Inspection of Equipment".

5.6 *Handling, Storage, Packaging and Delivery*

The Material Control and the Engineering & Fabrication Departments are both responsible for the proper handling of the components and completed magnet assemblies. Handling methods are defined with procedures and/or travelers, as appropriate.

The Material Control Department is responsible for the storage of most equipment, materials, completed assemblies, and related devices. The Material Control Department Head is responsible for establishing, documenting, communicating, and carrying out practices and procedures that ensure that items are stored and maintained to prevent damage, loss, or deterioration.

The Material Control and the Engineering & Fabrication Departments are both responsible for the proper packaging and delivery of the completed assemblies to CERN. Proper packaging methods are defined in packaging standards and/or drawings/specifications. Proper delivery methods are defined in the contract between Fermilab and the transporting organization.

The methods used to handle, store, package and delivery assemblies to CERN meet the requirements defined in section 15 of CERN QA document LHC-PM-QA-309.00 "Manufacturing and Inspection of Equipment".

5.7 *CERN Supplied Products*

CERN is responsible for providing the following components to the Project:

- MQXA (Q1 and Q3) cold masses (manufactured by KEK);
- MCBX, MCBXA and MQSXA corrector magnet assemblies;
- Quench protection heaters;
- Temperature sensors;
- Warm-up heaters (120 W);
- Beam tubes;
- Vacuum vessel bellows.

CERN is responsible for the quality of the components listed above. The Project is responsible for verification, storage and maintenance of the components after they have been received at Fermilab. Incoming inspection, proper handling and proper storage will ensure the quality of the CERN supplied components after they have been received.

Damaged components go through the QCR or DR process (see section 3.3), and are reported to CERN through appropriate channels. Lost components are also documented and reported to CERN through appropriate channels. The procedures used to handle material supplied by CERN meet the requirements defined in section 9 of CERN QA document LHC-PM-QA-309.00 "Manufacturing and Inspection of Equipment".

6.0 Design

6.1 *Policy*

The policy of the Technical Division is to ensure that designs perform as intended while minimizing cost. This is accomplished by having competent people incorporate sound engineering and scientific principles and appropriate technical standards into designs.

The design process used by the Project meets the requirements of CERN QA document LHC-PM-QA-307.00 "Design Process and Control".

6.2 *Design Input*

General design inputs are recorded in the CERN web-based "LHC Parameters and Layouts database". Design requirements specific to the US-LHC project were initially recorded in the Technical Design Handbook (TDH), and currently are defined in "Functional Specifications" (refer to section 5.4.1 of LHC-PM-QA-307.00 "Design Process and Control").

"Interface Specifications", for components interfacing with Fermilab-built magnets, are also used as inputs into the design process (refer to section 5.4.1 of LHC-PM-QA-307.00 "Design Process and Control")

6.3 *Design Output*

Interface Specifications, specific to Fermilab-built magnets, are design outputs. The purpose of interface specifications is to ensure that all groups are aware of the magnet assembly interfaces, and so that these groups are given the opportunity to review and provide feedback on these interfaces.

Drawings, material specifications and procurement specifications are outputs of the design process, and constitute the baseline design configuration. "Quality Assurance Categories" (QAC) are also an output of the design process and are recorded on the drawings, in accordance with CERN QA documents LHC-PM-QA-201.00 "Quality Assurance Categories" and LHC-PM-QA-306.00 "Drawing Process External Drawings". QACs are applied at the magnet level, and not at the component or part level, and have been defined to be category "B" for the magnet assembly.

The Project engineers are responsible for the creation and maintenance of the drawings and specifications for their portion of the Project.

All drawings and specifications are maintained as controlled documents (see section 4.4.1 of this document).

6.4 *Design Reviews*

At the conclusion of each phase of the Project, a documented, systematic, internal review is conducted to ensure that the final design and supporting data will meet design code requirements and standards. The reviews identify and anticipate problem areas, inadequacies, initiate corrective action, and includes representatives of all functions affecting quality as appropriate to the phase being reviewed. These formal reviews are used as a basis of assessing design reliability, ES&H, safety issues, quality problems, design improvement, and design practicality.

Results from the reviews are used as a basis for verifying that design outputs meet the design input requirements. More details regarding design reviews can be found in section 4.2.3 of the US-LHC Project Management Plan (PMP).

6.5 *Design Validation*

Designs are validated through the testing of the complete prototype system (or subsystem) during and after assembly, against the performance specifications. This testing includes the utilization of the Technical Division Magnet Test Facility (MTF).

6.6 *Design Changes*

Appropriate design controls are incorporated into the Project by using configuration management. Any changes to the magnet design, as defined in the drawings and specifications, must be reviewed and approved by the appropriate level of management (see section 5 of the US-LHC Project Management Plan, Change Management and Contingency Management - note that descriptions for change management in this section of the QA plan supercede the US-LHC Project Management Plan).

In practice, there are two types of change management processes. One for changes internal to the Project, and one for changes external to the Project.

Internal changes are changes that do not affect other systems outside of the scope of work for Fermilab. These changes are handled through the Technical Division ER/ECO procedure (5500-ES-360000). These changes do not need to be reviewed by the US-LHC Project Office, unless they affect configuration.

External changes are changes that have an impact on other systems outside the scope of work for Fermilab. An example is when a change affects how a CERN part will connect to the Fermilab-made magnet.

The overall change control process for external changes is as follows:

1. Proposed changes are recorded, in the form of updates to engineering specifications and drawings, and sent to the US-LHC Project Office.
2. The US-LHC Project Manager reviews the proposed changes, and:
    a) Sends them back to the Project for clarification;
    b) Approves the changes and places the document(s) into CERN EDMS for review by CERN; or
    c) Rejects the changes.
3. The proposed changes go through a review in CERN EDMS.
4. The proposed changes are approved and released in CERN EDMS, or are returned for revision or clarification.

7.0 Procurement

7.1 *Policy*

The Technical Division policy is to ensure that items and services provided by suppliers meet the requirements and expectations of the end-users at minimum cost.

7.2 *Requirements*

The Fermilab contract with the DOE specifies a variety of management controls to be applied to procurements and sub-contracts through the applicable DOE orders, DOE Acquisition Regulations (DEAR), and Federal Acquisition Regulations (FAR). To this end, all procurement activities are performed in accordance with the *Fermilab Procurement Policy and Procedures Manual* and the *Fermilab ES&H Manual*.

Only approved material is used in the production of the assemblies. The Material Control Department has the responsibility of procurement for the Project.

7.3 *Supplier Qualification and Selection*

Suppliers are evaluated and selected on the basis of their ability to meet subcontract requirements. These requirements are appropriately defined in approved engineering drawings and specifications, and include specific quality assurance requirements.

Topics that are usually evaluated include, but are not limited to:

- Quality assurance program
- Ability to meet all requirements
- Cost
- Financial resources
- Work history

7.4 *Budget Authority*

The Division Head, in conjunction with the budget defined by the US-LHC Project office, assigns expenditure level to individuals responsible for a specific work package. Procurement of items and services that are above the stated expenditure level require Division Head review and approval.

Expenditure levels are defined in the document *Technical Division Budget Codes & Signature Authority*, which is maintained on the fnts03 server.

7.5 *Make-Buy Decisions*

The fabrication of the magnet assemblies involves many "make or buy" decisions. The make-buy decision is based on a preference for providing hardware on a least-cost basis, giving due regard to such considerations as quality, capability and schedule. In general, bids are normally opened to outside suppliers. However, work will remain within Fermilab if it requires close engineering or scientific supervision, interaction between many trades or shops, involves materials or procedures not familiar to outside shops, or is dependent on capabilities unique to Fermilab.

8.0 Inspection and Acceptance Testing

8.1 *Policy*

The policy of the Technical Division is to ensure that all items, components, and services meet the specified requirements. This is verified through the use of inspection and acceptance testing.

8.2 *Requirements*

The Fermilab Project Manager and the Project engineers define the types of work that require formal inspections and acceptance testing. When an inspection or acceptance test is performed, the characteristics and processes to be inspected or tested, the inspection techniques to be used, the hold points, and the acceptance criteria are defined, as appropriate.

Inspection and acceptance testing (to include receiving, in-process, and final) are performed in accordance with proper training and/or written procedures.

The Material Control Department works with the Project personnel to define and document receiving acceptance testing for incoming materials. The traveler defines the testing during the assembly of the magnets (in-process). The agreement between the Project and CERN regarding weld inspections and qualification is defined in the document "Weld Inspections on FNAL Q2a and Q2b Quadrupoles".

The Magnet Test Facility (MTF) conducts the final performance testing of the completed assemblies. Cold tests of all the completed assemblies that are made from Fermilab-built cold masses will be performed, including quench training, field quality measurements and determination of the quadrupole axis. The first two completed assemblies made from KEK-built cold masses will be cold tested. The rest of the KEK-built quadrupoles will be tested at room-temperature for field axis measurements. The complete MTF test plans are defined in "run plan" documents.

All equipment which effects product quality (or is used to make a decision which effects product quality) is calibrated at prescribed intervals, and is appropriately identified with its calibration status. In general, calibration reference standards are traceable to NIST or other national/international organizations. If no national standard exists then the basis used for calibration is appropriately documented.

The procedures and practices used by the Project for inspections and calibrations meet the requirements of sections 8, 11 and 13 of the CERN QA document LHC-PM-QA-309.00 "Manufacturing and Inspection of Equipment".

8.3 *Records*

To allow for traceability, adequate records are maintained for all inspections and tests. These records include observations made, inspection/test results, identification of the personnel conducting the inspection/test, and date. Refer to section 4.3.3 for more details regarding records.

9.0 Quality Assessment

9.1 *Policy*

The policy of the Technical Division is to regularly assess the division's effectiveness in meeting it's objectives, goals, and compliance to orders and regulations. This is accomplished using the Technical Division Self-Assessment Program.

9.2 *Requirements*

Technical Division management will evaluate the division's role in the Project, in order to ensure that the Division continues to fulfill the requirements of the Project.

Management systems for performing and assessing adequacy of work on the Project, including activities that relate to planning, scheduling, and cost control are described in the following documents:

1. US-LHC Project Management Plan
2. Technical Division Quality Management Program
3. Technical Division Self-Assessment Program

9.3 *Methods*

Details from the TD Self-Assessment Program are not repeated here. Assessments are made using formal and informal meetings and other communications. Examples are:

- Division Head meeting with department heads or other supervisory staff
- Department heads meeting with line supervisors and other lead personnel
- Suggestions and recommendations from Project personnel
- Design Reviews & Production Readiness Reviews
- Independent assessments

9.4 *Feedback*

Information gathered during assessments is used to provide feedback to Project personnel. This information allows Project personnel to make improvements and any necessary corrective/preventive actions, so that the goals of the Project may be met.

Revision History

Version	Date	Section No.	Specifics
1	21-Nov-2001	All	First version

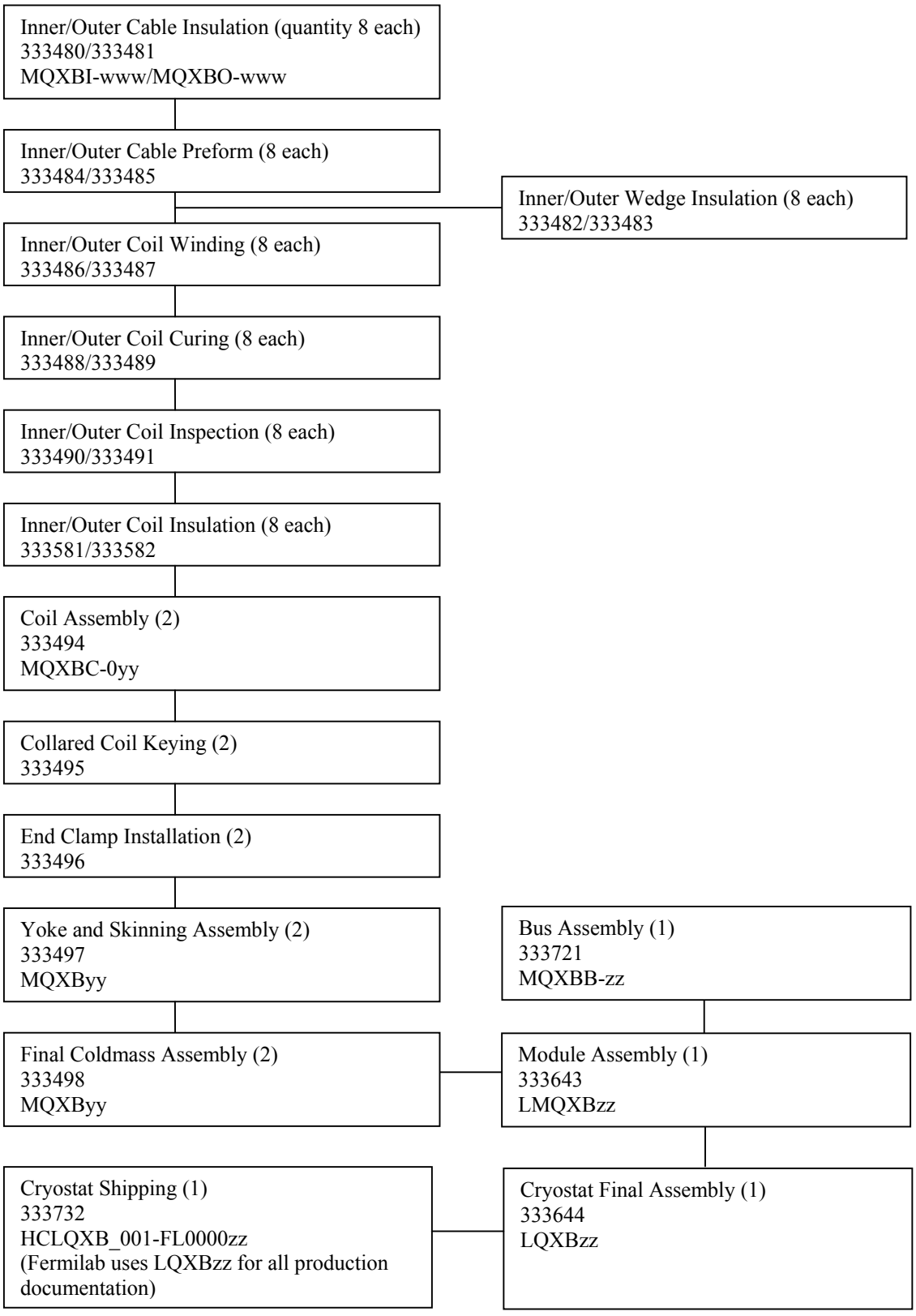
Controlled Distribution

Technical Division library	
Fermilab Project Manager	Jim Kerby
Technical Division Quality Assurance Officer	Jamie Blowers
US-LHC Project Office	Phil Pfund

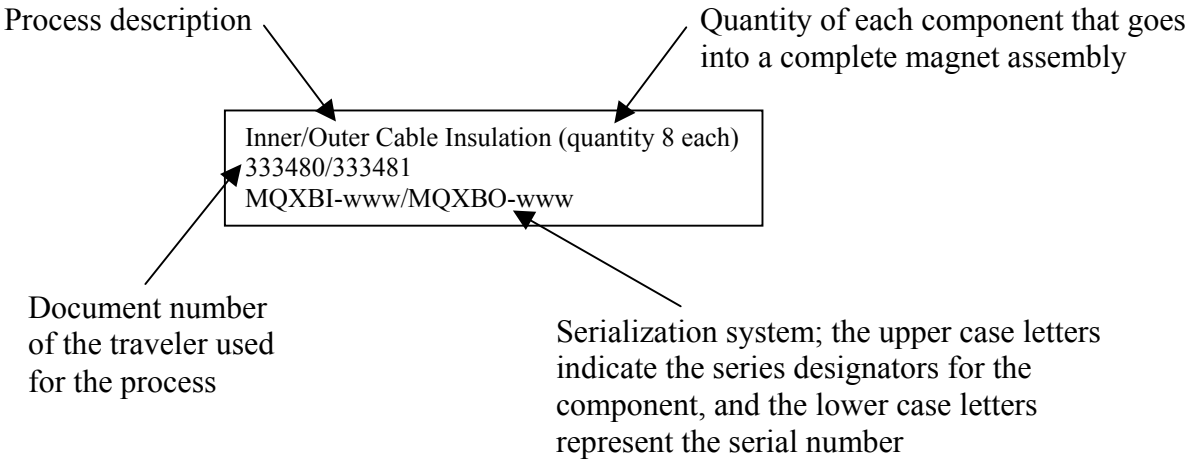
Revisions:

24-Nov-2001	Original
24-April-2002	Added Jamie Blowers; and changed John Carson to Jim Kerby (Tooling 1.1.1.1)

Q2 Assembly Workflow



Interpretation of the assembly workflow:



Revisions:

21-Nov-2001	Original
24-April-2002	Removed Yoke Stacking boxes becuase they are now being stacked outside Fermilab
01-July-2002	Added comment regarding Fermilab using LQXBzz for final assembly (333644)
15-April-2003	Added MQXBB Bus Assembly (333721)
03-Feb-2005	Added Cryostat Shipping Traveler (333732)